PATENT ABSTRACTS OF JAPAN

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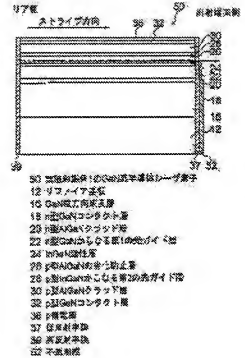
(54) SEMICONDUCTOR LASER ELEMENT AND OPTICAL INTEGRATED DEVICE

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a semiconductor laser element emitting the light of a single peaked waveguide mode.
SOLUTION: A GaN semiconductor laser element 50 has the same constitution as a conventional GaN semiconductor laser element 10, except that the end faces of a sapphire substrate 12, a GaN lateral direction growing layer 14 and an n-type GaN contact layer 16 on an emitting end face side are not covered with an opaque film 52 formed of a material opaque to the oscillation wavelength of the GaN semiconductor laser element 50. The sapphire substrate 12, the GaN lateral direction growing layer 14 and the n-type GaN contact layer 16 have refractive indexes larger than the effective refractive index of light at the waveguide mode, and are transparent to the light of the oscillation wavelength. Consequently, the end face of the emitting end face side is covered by the opaque film 52 for shielding the light of a substrate radiation mode. An optical waveguide upper than an n-type AlGaN clad layer 20 is not covered with the opaque film 52.



CLAIMS

[Claim(s)]
[Claim 1]A semiconductor laser element, wherein the end face of a laminated structure by the side of an emitting end surface is covered by an opaque film which does not penetrate light of an oscillation wavelength of a semiconductor laser element in a semiconductor laser element which has on a substrate optical waveguide structure and a laminated structure of a compound semiconductor layer provided under optical waveguide structure.
[Claim 2]The semiconductor laser element according to claim 1, wherein a board edge side by the side of an emitting end surface is covered by said opaque film.
[Claim 3]A semiconductor laser element, wherein a board edge side by the side of an emitting end surface is covered by an opaque film which does not penetrate light of an oscillation wavelength of a semiconductor laser element in a semiconductor laser element which has optical waveguide structure on a substrate without making

a compound semiconductor layer intervene.
[Claim 4]A semiconductor laser element given in any 1 paragraph of the claims 1-3, wherein said opaque film is formed by an optical absorption nature dielectric film which absorbs light in which a semiconductor laser element emits light, or optical absorption nature semiconductor membrane.
[Claim 5]A semiconductor laser element given in any 1 paragraph of the claims 1-3, wherein said opaque film is formed with a light reflection film which reflects light in which a semiconductor laser element emits light.
[Claim 6]An optical integrated device which is provided with the following and characterized by a board edge side by the side of an emitting end surface having met a light shielding film of an optic in a gap of mum order.
A semiconductor laser element which has optical waveguide structure on a substrate without making a compound semiconductor layer intervene.
An optic which has at least a light shielding film which intercepts light in a part of outside.

[Claim 7]An optical integrated device which is provided with the following and characterized by the end face of a laminated structure by the side of an emitting end surface, or the end face and a board edge side of a laminated structure having met a light shielding film of an optic in a gap of mum order.
Optical waveguide structure.
A semiconductor laser element which has on a substrate a laminated structure of a compound semiconductor layer provided under optical waveguide structure.
An optic which has at least a light shielding film which intercepts light in a part of outside.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]More particularly, this invention relates to the semiconductor laser element which shows a monophasic far field pattern about a semiconductor laser element.
[0002]
[Description of the Prior Art]The GaN system semiconductor laser element provided with the laminated structure of a GaN system compound semiconductor layer on silicon on sapphire or a GaN board attracts attention as a light emitting device which emits light in the light of a short wavelength region which results green from an ultraviolet region.
[0003]Here, the composition of the conventional semiconductor laser element is explained with reference to drawing 4. Drawing 4 is a sectional view showing the composition of the conventional GaN system semiconductor laser element. As shown in drawing 4, the conventional GaN system semiconductor laser element 10 via the GaN transverse direction growth phase 16 on the convex GaN seed crystal section 14 provided on the silicon on sapphire 12 of c side. The n type GaN contact layer 18, the n type AlGaN clad layer 20, the 1st light guide layer 22 that consists of n type GaN, the InGaN active layer 24, the deterioration prevention layer 26 of p type AlGaN which prevents degradation of the active layer 24, the 2nd light guide layer 28 that consists of p type InGaN, It has the laminated structure which laminated the p type AlGaN clad layer 30 and the p type GaN contact layer 32 one by one. The 1st light guide layer 22, 2nd light guide layer 28, and deterioration prevention layer 26 may not be provided.
[0004]The upper levels and the p type contact layer 32 of the p type clad layer 30 are formed in one way as a ridge stripe part prolonged in the shape of a ridge stripe. The lower layer part of the upper levels of the n type

contact layer 18, the n type clad layer 20, the 1st light guide layer 22, the active layer 24, the deterioration prevention layer 26, the 2nd light guide layer 28, and the p type clad layer 30 is formed as a mesa part which extends in the same direction as a ridge stripe part.

[0005]The n type contact layer 18 of the both sides of a ridge stripe part, a mesa part, and a mesa part is covered with the protective film 34 which consists of a SiO_2 film except for the openings 34a and 34b provided in the upper surface of a ridge stripe part, and the partial area of the n type contact layer 18, respectively. On the p type contact layer 32, the p lateral electrode 36 of a multilevel-metal film like nickel/Au electrode is formed as an ohmic junction electrode via the opening 34a. On the n type contact layer 18, the n lateral electrode 38 of a multilevel-metal film like Ti/Al electrode is formed as an ohmic junction electrode via the opening 34b.

[0006]Another conventional GaN system semiconductor laser element 40. As shown in drawing 5, it replaces with silicon on sapphire and has a laminated structure of the lower layer part of the p type clad layer 30 from the n type clad layer 20 to the 2nd light guide layer 28, and the upper levels of the p type clad layer 30 and the ridge stripe part of the p type contact layer 32 directly on the n type GaN board 42. The n lateral electrode 44 is formed in the rear face of the n type GaN board 42 using the conductivity of a GaN board.

[0007]In the conventional GaN system semiconductor laser elements 10 and 40 constituted as mentioned above. Reduction of actuating current is attained by forming the upper levels and the p type contact layer 32 of the p type clad layer 30 as a ridge stripe part, and restricting the size of the current path of an inrush current, and horizontal microfiche is controlled by effective refractive index difference of the transverse direction of a ridge stripe part.

[0008]

[Problem(s) to be Solved by the Invention]By the way, the far field pattern (it is perpendicularly to an active layer) of the laser beam emitted by 30.0 mW of optical power from the conventional semiconductor laser elements 10 and 40 mentioned above, As shown in drawing 6 (a), with the curve (1) which shows a lengthwise direction ingredient, the peak A corresponding to substrate radiation mode (refer to drawing 6 (b)) laps with the far field pattern (refer to drawing 6 (c)) of single Mine corresponding to guided mode, and is observed. A curve (2) is a transverse direction ingredient of a far field pattern.

[0009]However, when the semiconductor laser element which shows such a far field pattern is used as the light source of the optical pickup of an optoelectronic memory system, Light of substrate radiation mode cannot be condensed in the lens designed so that the guided mode of what has required condensing a laser beam to a diffraction limit with a lens might condense to a diffraction limit. That is, the light of substrate radiation mode turns into the stray light which has an adverse effect which it is not only a useless unnecessary light which is not used for the writing to optical memory, read-out, etc., but is referred to as making the writing of an optoelectronic memory system, read-out, etc. produce an error conversely.

[0010]Therefore, the light of substrate radiation mode is removed in this way, and the GaN system semiconductor laser element which shows the single Mine far field pattern which consists only of light of guided mode is called for. Although the GaN system semiconductor laser element was made into the example and the problem was explained by the above explanation, this problem corresponds to a semiconductor laser element not only a GaN system but at large.

[0011]Then, the purpose of this invention is to provide the semiconductor laser element which emits the light of monophasic guided mode.

[0012]

[Means for Solving the Problem]Here, with reference to drawing 7, guided mode light intensity distribution of a typical semiconductor laser element is explained. Drawing 7 is a mimetic diagram showing luminous-intensity distribution of guided mode of a semiconductor laser element in a section of line I-I of drawing 4, and a section of line II-II of drawing 5. As shown in drawing 7, a maximum peak of light intensity is located in the active layer 24, and is decreased within the p type clad layer 30 and the n type clad layer 20. Although distribution of light of guided mode exists also in the substrate side further from the n type clad layer 20, the great portion of luminous energy of guided mode is in a range from the p type clad layer 30 to the n type clad layer 20, and the physical thickness is 2 micrometers ~ at most 3 micrometers.

[0013]By the way, generating conditions of light of substrate radiation mode are that the material layer B which adjoins the substrate side further is more transparent to a luminous wavelength of a semiconductor laser element than to the n type clad layer 20, and that an effective index of light of guided mode is smaller than a refractive index of the material layer B. In the GaN system semiconductor laser element 40 which are the GaN transverse direction growth phase 16 and the n type contact layer 18, and also the silicon on sapphire 12, and is shown in drawing 5 by the GaN system semiconductor laser element 10 indicated here to be the material layer B which adjoins a substrate to drawing 4, it is the GaN board 42. In lamination of the conventional semiconductor

laser elements 10 and 40 mentioned above, since a generating condition of such substrate radiation mode is satisfied, light of substrate radiation mode occurs.

[0014]Light of substrate radiation mode is generated by combination with light of guided mode, as shown in drawing 8. Supposing propagation in the material layer B is the angle theta 1 and is emitted to a slanting lower part at the angle theta 2 to propagation (parallel to a substrate) of light of guided mode from the light-emitting surface (emitting end surface) C of a semiconductor laser element, light of substrate radiation mode. Between theta 1, n_{sub}, and n_{eff}, a relation expressed with cos(theta 1) $=n_{eff}/n_{sub}$ is materialized. Here, n_{eff} and a refractive index of the material layer B are made into n_{sub} for an effective index of light of guided mode.

[0015]A relation of the following formula is materialized between theta 2, n_{sub}, and n_{eff}.

Light emitted outside at the sin(theta 2) xsin(theta 2) $=n_{sub}xn_{sub}-n_{eff}xn_{eff}$ angle theta 2 becomes the side peaks A of drawing 6 (a). Light of substrate radiation mode is emitted from the light-emitting surface C through the material layer B, and since thickness of a field of a path of light of substrate radiation mode becomes large according to thickness of the material layer B, it is usually in the range of hundreds of [several to] micrometers.

[0016]As mentioned above, the great portion of light of guided mode of a semiconductor laser element which shows a monophasic far field pattern is emitted from the light-emitting surface C of a range from a p type clad layer to a n type clad layer. On the other hand, substrate radiation mode which forms the side peaks A (refer to drawing 6 (a)) is emitted from the light-emitting surface C through the material layer B which adjoins the substrate side further from a n type clad layer into a far field pattern. Therefore, in order to obtain a semiconductor laser element which shows a monophasic far field pattern, as shown in drawing 9, it is effective to cover light of substrate radiation mode emitted from the material layer B in the light-emitting surface C with a light shielding film.

[0017]To achieve the above objects, a semiconductor laser element (henceforth the 1st invention) which starts this invention based on above-mentioned knowledge, In a semiconductor laser element which has on a substrate optical waveguide structure and a laminated structure of a compound semiconductor layer provided under optical waveguide structure, the end face of a laminated structure by the side of an emitting end surface is characterized by being covered by an opaque film which does not penetrate light of an oscillation wavelength of a semiconductor laser element.

[0018]Suitably, a board edge side by the side of an emitting end surface is further covered by an opaque film which does not penetrate light of an oscillation wavelength of a semiconductor laser element.

[0019]About that by which optical waveguide structure is directly formed on a substrate. Another semiconductor laser element (henceforth the 2nd invention) concerning this invention, In a semiconductor laser element which has optical waveguide structure on a substrate, a board edge side by the side of an emitting end surface is characterized by being covered by an opaque film which does not penetrate light of an oscillation wavelength of a semiconductor laser element, without making a compound semiconductor layer intervene.

[0020]Unless an opaque film of the 1st and the 2nd invention penetrates light of an oscillation wavelength of a semiconductor laser element, there are no restrictions, for example, an opaque film is formed by an optical absorption nature dielectric film which absorbs light in which a semiconductor laser element emits light, or optical absorption nature semiconductor membrane. For example, a bandgap wavelength uses semiconductor membrane smaller than an oscillation wavelength of a semiconductor laser element for optical absorption nature semiconductor membrane. An opaque film may be formed with light reflection films, such as a metal membrane which reflects light in which a semiconductor laser element emits light. It may be formed by a dielectric multilayer designed so that an opaque film might reflect light in which a semiconductor laser element emits light.

[0021]The end face and a board edge side of a laminated structure by the side of an emitting end surface replace with an opaque film, and may be covered with an optic formed with material which intercepts light. That is, optical waveguide structure about what is directly provided on a substrate. An optical integrated device (henceforth the 3rd invention) concerning this invention, A semiconductor laser element which has optical waveguide structure on a substrate without making a compound semiconductor layer intervene. It has an optic which has at least a light shielding film which consists of material which intercepts light in a part of outside, and a board edge side by the side of an emitting end surface is characterized by having met a light shielding film of an optic in a gap of mum order.

[0022]About that by which optical waveguide structure is established on a substrate via a laminated structure of a compound semiconductor layer. Another optical integrated device (henceforth the 4th invention) concerning this invention, A semiconductor laser element which has on a substrate optical waveguide structure and a laminated structure of a compound semiconductor layer provided under optical waveguide structure. It has an optic which has at least a light shielding film which consists of material which intercepts light in a part of outside.

and the end face of a laminated structure by the side of an emitting end surface, or the end face and a board edge side of a laminated structure is characterized by having met a light shielding film of an optic in a gap of mum order.
[0023]Optics of the 3rd and the 4th invention are parts usually functionally connected with a semiconductor laser element, for example, are apertures (spatial filter) etc. In the 3rd and 4th inventions, by arranging an aperture (spatial filter), it can become equivalent to arranging a light shielding film to an emitting end surface of a semiconductor laser element, high frequency components of a far field pattern can be reduced, and a smoother far field pattern can be obtained.
[0024]
[Embodiment of the Invention]With reference to an accompanying drawing, the example of an embodiment is given to below and an embodiment of the invention is described to it concretely and in detail.
The example of the one example embodiment of an embodiment is an example of the embodiment which applied the semiconductor laser element concerning the 1st invention to the GaN system semiconductor laser element formed on silicon on sapphire, Drawing 1 is a figure showing the composition of the GaN system semiconductor laser element of this example of an embodiment, and is a sectional view equivalent to the section in line I-I of drawing 4. The GaN system semiconductor laser element 50 of this example of an embodiment, As shown in drawing 1, the end face of the silicon on sapphire 12 by the side of an emitting end surface, the GaN transverse direction growth phase 16, and the n type GaN contact layer 18, Except for being covered by the opaque film 52 which does not penetrate the oscillation wavelength of the GaN system semiconductor laser element 50, and 405-nm light, it has the same composition as the conventional GaN system semiconductor laser element 10.
[0025]In this example of an embodiment, the silicon on sapphire 12, the GaN transverse direction growth phase 16, and the n type GaN contact layer 18, It is a bigger refractive index than the effective index of the light of guided mode, and since it is a transparent material to the light of an oscillation wavelength, in order to cover the light of substrate radiation mode, the end face by the side of an emitting end surface is covered by the opaque film 52. On the other hand, the upper optical waveguide is not covered by the opaque film 52 from the n type AlGaN clad layer 20.
[0026]The opaque film 52 is laminated on the low reflectance film 37 provided in the emitting end surface of the conventional GaN system semiconductor laser element 10. In this example of an embodiment, the light absorption film which formed membranes by the sputtering technique, for example, the Si film whose thickness is 100 nm, is used as the opaque film 52. The light reflection film which consists of a metal membrane which, for example, made metal, such as a high reflectance film which consists of a multilayer dielectric film of a SiO_2 film and a TiO_2 film or Ti, and aluminum, vapor-deposit as an opaque film in addition to a light absorption film may be sufficient. The opaque film 52 may be formed and the low reflectance film 37 may be laminated on it. The high reflectance film 39 is formed in the rear side opposite to an emitting end surface from the former.
[0027]In this example of an embodiment, the light of substrate radiation mode is covered by using a light absorption film as the opaque film 52. Thereby, the GaN system semiconductor laser element 50 can emit the light of the guided mode which shows a monophasic far field pattern.
[0028]The example of the two example embodiment of an embodiment is an example of the embodiment which applied the semiconductor laser element concerning the 2nd invention to the GaN system semiconductor laser element formed on the GaN board, Drawing 2 is a figure showing the composition of the GaN system semiconductor laser element of this example of an embodiment, and is a sectional view equivalent to the section in line II-II of drawing 5. The GaN system semiconductor laser element 60 of this example of an embodiment, As shown in drawing 2, the end face of the GaN board 42 by the side of an emitting end surface is provided with the same composition as the conventional GaN system semiconductor laser element 40 except for being covered by the opaque film 62 which does not penetrate the oscillation wavelength of the GaN system semiconductor laser element 60, and 405-nm light.
[0029]In this example of an embodiment, the GaN board 42 is a bigger refractive index than the effective index of the light of guided mode, and since it is a transparent material to the light of an oscillation wavelength, in order to cover the light of substrate radiation mode, the end face by the side of an emitting end surface is covered by the opaque film 62. On the other hand, the upper optical waveguide is not covered by the opaque film 62 from the n type AlGaN clad layer 20.
[0030]The opaque film 62 is laminated on the low reflectance film 46 provided in the emitting end surface of the conventional GaN system semiconductor laser element 40. In this example of an embodiment, the light absorption film, for example, the Si film of 100 nm of thickness, is used as the opaque film 62. The light reflection film which consists of a metal membrane which, in addition to this, made metal, such as a high reflectance film which consists of a multilayer dielectric film of a SiO_2 film and a TiO_2 film or Ti, and aluminum, vapor-deposit as

an opaque film for example may be sufficient. The opaque film 62 may be formed and the low reflectance film 46 may be laminated on it. The high reflectance film 48 is formed in the rear side opposite to an emitting end surface from the former.

[0031]In this example of an embodiment, the light of substrate radiation mode is covered by using a light absorption film as the opaque film 62. Thereby, the GaN system semiconductor laser element 60 can emit the light of the guided mode which shows a monophasic far field pattern.

[0032]The example of the three example embodiment of an embodiment is an example of the embodiment of the optical integrated device concerning the 3rd invention, and drawing 3 is a sectional view showing the composition of the optical integrated device of this example of an embodiment. The GaN system semiconductor laser element of drawing 3 is shown by the section equivalent to the section in line II-II of drawing 5. As the optical integrated device 72 of this example of an embodiment is a device provided with the GaN system semiconductor laser element 70 and the optic 80 and it is shown in drawing 3, The GaN system semiconductor laser element 70 provided with the same composition as the conventional semiconductor laser element 40 shown in drawing 5 is joined on the semiconductor substrate 74 by the junction down. It was joined to the heat sink 76 the GaN system semiconductor laser 70 junction-side in the opposite hand, and the semiconductor substrate 74 is provided with the photo-diode 78 in parallel with the GaN system semiconductor laser element 70.

[0033]In this example of an embodiment, it was joined by the end face of the heat sink 76 in the adhesives layer 79, and the end face of the GaN board 42 by the side of the emitting end surface of the GaN system semiconductor laser element 70 has met the light shielding film 82 provided in the optic 80 which intersects perpendicularly with the heat sink 76 and stands straight in the gap of several micrometers or less. The optic 80 is an optic called what is called aperture (spatial filter) in this example of an embodiment, The nonreflective film 84 equips both sides with the light shielding film 82 which becomes a field which meets the GaN board 42 of the GaN system semiconductor laser element 70 of one field of the transparent substrate 86 by which spreading membrane formation was carried out, for example from the Si film of 100 nm of thickness. On the other hand, the end face of the optical waveguide formed on the GaN board 42 of the GaN system semiconductor laser element 70 faces the nonreflective film 84 of the optic 80.

[0034]In this example of an embodiment, the light of the guided mode emitted from the GaN system semiconductor laser element 70, Since the light of substrate radiation mode is interrupted with the light shielding film 82 provided in the optic 80 while penetrating the optic 80, the GaN system semiconductor laser element 70 can emit the light of the guided mode which shows a monophasic far field pattern.

[0035]

[Effect of the Invention]According to the 1st and 2nd inventions, the semiconductor laser element which shows a monophasic good far field pattern is realized by covering the light of substrate radiation mode among the lights emitted from a semiconductor laser element, and emitting only the light of guided mode from an optical waveguide end face. In the 3rd and 4th inventions, by arranging an aperture (spatial filter), it can become equivalent to arranging a shelter to the emitting end surface of a semiconductor laser element, the high frequency components of a far field pattern can be reduced, and a smoother far field pattern can be obtained.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1]It is a sectional view equivalent to the section in line I-I of drawing 4 showing the composition of the GaN system semiconductor laser element of the example 1 of an embodiment.

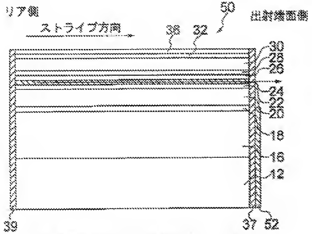
[Drawing 2]It is a sectional view equivalent to the section in line II-II of drawing 5 showing the composition of

the GaN system semiconductor laser element of the example 2 of an embodiment.
[Drawing 3]It is a sectional view showing the composition of the optical integrated device provided with the GaN system semiconductor laser element of the example 3 of an embodiment.
[Drawing 4]It is a sectional view showing the composition of the conventional GaN system semiconductor laser element.
[Drawing 5]It is a sectional view showing the composition of another conventional GaN system semiconductor laser element.
[Drawing 6]The light intensity distribution of the lengthwise direction ingredient of the far field pattern (it is perpendicularly to an active layer) of a laser beam and a transverse direction ingredient is shown, drawing 6 (b) shows the far field pattern of the light of guided mode, and, as for drawing 6 (a), drawing 6 (c) shows the optical far field pattern of substrate radiation mode.
[Drawing 7]It is a mimetic diagram showing the intensity distribution of the element perpendicular direction of the film constitution in a semiconductor laser element, and the light of guided mode.
[Drawing 8]It is a figure in which making it related with the film constitution of a semiconductor laser element, and showing propagation of the light of guided mode, and the light of substrate radiation mode.
[Drawing 9]It is a mimetic diagram explaining the gist of this invention.
[Description of Notations]
10 .... The conventional GaN system semiconductor laser element, 12 .... Silicon on sapphire, 16 .... A GaN transverse direction growth phase, 18 .... A n type GaN contact layer, 20 .... N type AlGaN clad layer, 22 .... The 1st light guide layer, 24 which consist of n type GaN .... InGaN active layer, 26 .... The deterioration prevention layer of p type AlGaN, 28 .... The 2nd light guide layer that consists of p type InGaN, 30 .... A p type AlGaN clad layer, 32 .... P type GaN contact layer, 34 .... A SiO_2 film, 36 .... p lateral electrode, 37 .... Low reflectance film, 38 .... n lateral electrode, 39 .... A quantity reflectance film, 40 .... Another conventional GaN system semiconductor laser element, 42 .... A n type GaN board, 44 .... n lateral electrode, 46 .... Low reflectance film, 48 .... A quantity reflectance film, 50 .... The GaN system semiconductor laser element of the example 1 of an embodiment, 52 .... An opaque film, 60 .... The GaN system semiconductor laser element of the example 2 of an embodiment, 62 [.... A semiconductor substrate, 76 / .... A heat sink, 78 / .... A photo-diode, 79 / .... An adhesives layer, 80 / .... An optic, 82 / ---- A light shielding film, 84 / .... A nonreflective film, 86 / .... Transparent substrate.] .... An opaque film, 70 .... The GaN system semiconductor laser element of the example 3 of an embodiment, 72 .... An optical integrated device, 74

[Translation done.]

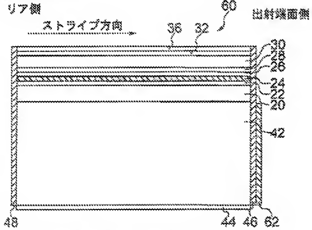
DRAWINGS

[Drawing 1]



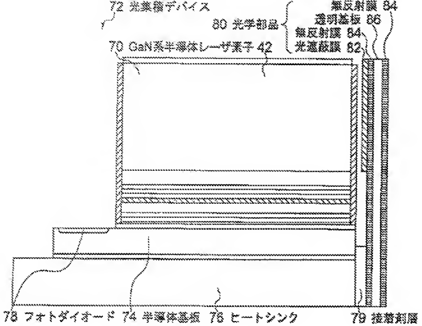
50 実施形態例1のGaN系半導体レーザ素子
12 サファイア基板
16 GaN横方向成長層
18 n型GaNコンタクト層
20 n型AlGaNクラッド層
22 n型GaNからなる第1の光ガイド層
24 InGaN活性層
26 p型AlGaNの劣化防止層
28 p型InGaNからなる第2の光ガイド層
30 p型AlGaNクラッド層
32 p型GaNコンタクト層
36 p側電極
37 低反射率膜
39 高反射率膜
52 不透明膜

[Drawing 2]

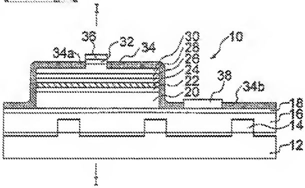


60 実施形態例2のGaN系半導体レーザ素子
20 n型AlGaNクラッド層
22 n型GaNからなる第1の光ガイド層
24 InGaN活性層
26 p型AlGaNの劣化防止層
28 p型InGaNからなる第2の光ガイド層
30 p型AlGaNクラッド層
32 p型GaNコンタクト層
36 p側電極
42 n型GaN基板
44 n側電極
46 低反射率膜
48 高反射率膜
62 不透明膜

[Drawing 3]

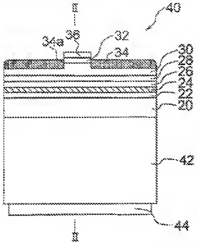


[Drawing 4]



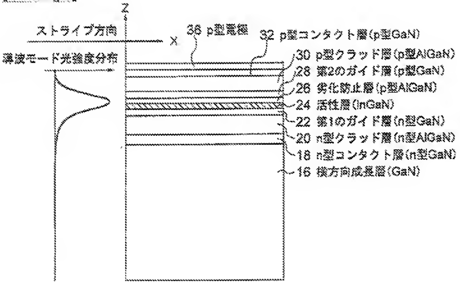
10 従来のGaN系半導体レーザ素子
12 サファイア基板
14 GaN種結晶部
16 GaN横方向成長層
18 n型GaNコンタクト層
20 n型AlGaNクラッド層
22 n型GaNからなる第1の光ガイド層
24 InGaN活性層
26 p型AlGaNの劣化防止層
28 p型InGaNからなる第2の光ガイド層
30 p型AlGaNクラッド層
32 p型GaNコンタクト層
34a, 34b 開口部
34 SiO_2膜からなる保護膜
36 p側電極
38 n側電極

[Drawing 5]

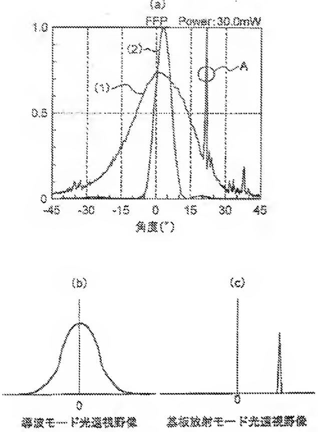


40 従来の別のGaN系半導体レーザ素子
20 n型AlGaNクラッド層
22 n型GaNからなる第1の光ガイド層
24 InGaN活性層
26 p型AlGaNの劣化防止層
28 p型InGaNからなる第2の光ガイド層
30 p型AlGaNクラッド層
32 p型GaNコンタクト層
34a 開口部
34 SiO_2膜からなる保護膜
36 p側電極
42 n型GaN基板
44 n側電極

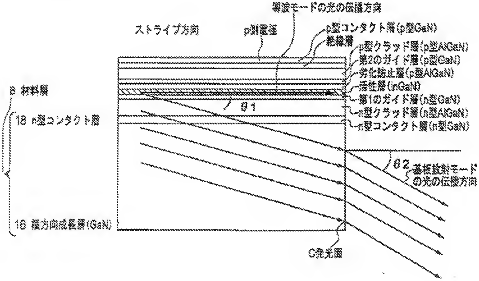
[Drawing 7]



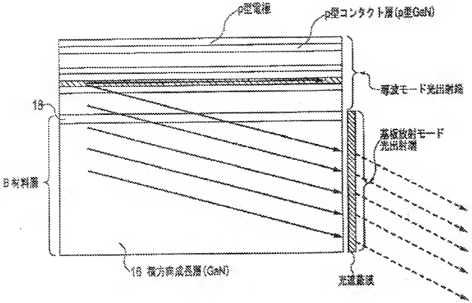
[Drawing 6]



[Drawing 8]



[Drawing 9]



[Translation done.]